WATER

WATER

WATER

WATER

WATER

WATER

WATER

WATER

WATER

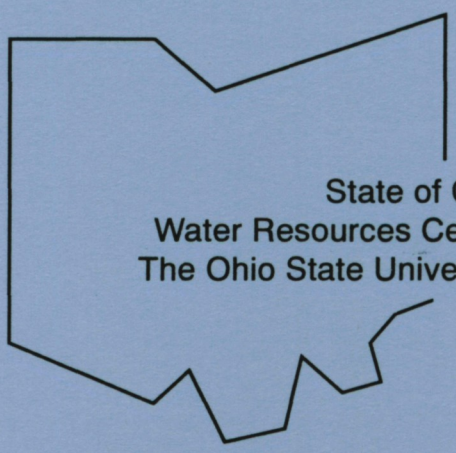
WATER

Report No. G-2039-05

FISCAL YEAR 1994 PROGRAM REPORT

Robert C. Stiefel
Director

United States
Geological Survey



State of Ohio
Water Resources Center
The Ohio State University

FISCAL YEAR 1994 PROGRAM REPORT

Ohio Water Resources Center
The Ohio State University
Ohio

Report No.
G-2039-01-05

Fiscal Year 1994 Program Report
Grant No. 14-08-0001-G 2039-05

for

U. S. Department of the Interior
Geological Survey

by

Ohio Water Resources Center
The Ohio State University
Columbus, Ohio 43210

Robert C. Stiefel, Director

September, 1995

The activities on which this report is based were financed in part by the Department of the Interior, U. S. Geological Survey, through the Ohio Water Resources Center.

The contents of the publication do not necessarily reflect the views and policies of the Department of the Interior, nor does mention of trade names or commercial products constitute their endorsement by the United States Government.

ABSTRACT

Most of Ohio's water problems are associated with water quality. Of primary concern are the sediments, nutrients and acids in the surface waters from urban, agricultural and mining areas, and the toxic and hazardous wastes that threaten the ground and surface waters. The focus of the 1994 State Water Research Program was directed at these areas. The research and technology transfer program consisted of the following activities. The technology transfer programs of the Water Resources Center continue to disseminate information about the water resources of Ohio to the local and state decision makers, a nd provides technical assistance to help resolve some of the state's major water problems. One project was an oceanographic dynamics study, for Lake Erie, which used mathmatical models to calculate how contaminant loading from rivers will interact with the Great Lakes Forecasting System. This project will provide accurate and timely loading figures for the forecasting system. The ground water testing for radium and uranium in Ohio's waters, studied the transport and chemistry of these radioactive chemicals. This was the first study of this type in Ohio and included the DOE sites near Fernald and Portsmouth. The fate and transport research studied the effects of aqueous-organic cosolvent mixtures on the environmental chemistry of toxic metal-ligand complexes.

Training on these research projects was provided to three Ph. D. Students from three disciplines at three universities, (The Ohio State University, Case Western Reserve University and John Carroll University). The disciplines include Hydrogeology, Agronomy and Civil and Environmental Engineering in the departments of Geological Sciences, the School of Natural Resources in the College of Agriculture and the Department of Civil Environmental and Engineering Graphics in the the College of Engineering.

The information transfer project included training 140 people in two-day workshops to teach Project WET materials. These individuals in turn will each teach at at least ten others to use Project WET materials. In addition the Center has sponsored or co-sponsored seminars, annual meetings and programs totaling more than 1,000 attendees during the year. Other information transfer activies for the Center included the newsletter, and making presentations for the Ohio Water Education Program to many audiences.

Table of Contents

Water Problems and Issues of Ohio

Water is one of Ohio's most important natural resources. Bounded on the north by Lake Erie and on the south by the Ohio River and containing other extensive ground and surface waters, Ohio has an adequate supply of water to meet its immediate needs. However, the combination of large, heavily industrialized urban centers; extensive agricultural activities; high volume coal production and large coal reserves; and the associated demands of new energy production continues to cause concerns related to water quality and water management. In addition, extreme hydrologic events cause localized problems of both excessive water and deficiencies at times.

Surface Water

The northern 25 percent of Ohio's area drains into Lake Erie, while the southern portion drains into the Ohio River. Runoff from Ohio's streams and rivers averages about 25 billion gallons per day. The state also receives nearly a billion gallons of runoff daily which drains through the Maumee River to Lake Erie from the neighboring state of Indiana; and Ohio has access to additional flows past its boundaries in Lake Erie and the Ohio River that total well over 150 billion gallons of water per day.

Last year, more than 16 billion gallons of water were withdrawn from Ohio's surface sources each day to meet the demands for municipal supplies; rural needs for domestic and livestock purposes; irrigation; and self-supplied industrial needs including cooling water for thermo-electric power generation. These demands account for only 60 percent of the available surface waters in the state's streams each day, and localized shortages only develop during certain dry seasons and periodic droughts.

The combined length of all the streams in Ohio approaches 44,000 miles, which means that there is approximately one mile of stream for each square mile of surface area in the state. In addition, there are more than 50,000 lakes, ponds and reservoirs within the state having a combined surface area of 200,000 acres. Only a small fraction of these, about 6,700 acres, occur naturally. The remainder are man-made impoundments that range in size from small farm ponds to large multipurpose reservoirs.

The reservoirs in the state are used to provide water for many different purposes including municipal, agricultural and industrial supplies; stream flow augmentation; flood control; and recreation. No impoundments in Ohio, other than those on the main stem of the Ohio River, provide water for downstream navigation or hydro-electric power generation. However, there is extensive navigation on both Lake Erie and the Ohio River, and consideration is being given to the installation of low-head hydro-electric generators at several developed dam sites throughout the state.

Flooding, still a major problem in Ohio, affects both urban and agricultural areas; and it has been estimated that nearly two million acres of land in Ohio are flood prone. This represents over seven percent of the total area of the state and includes nearly four percent of those areas classified as urban regions. Average annual flood damages in Ohio vary from year-to-year but amount to several millions of dollars annually.

Ground Water

Ground water is an important part of Ohio's water resources. Ground water underlies most of the state but is predominant in the glacial drift in the northwest, in the ice-contact and outwash deposits in river valleys along the border of the glaciated areas, and in the bedrock of the western portions of the state. Ground water supplies are largest in the glacial valley-train deposits in those drainage basins which border the Ohio River including the Ohio, Miami, Little Miami, Scioto, Hocking and Muskingum Rivers. Well yields from these deposits often exceed 500 gallons per minute (gpm), while aquifers in the glacial drift in the northwest and west-central parts of the state produce yields between 100 and 500 gpm. With the exception of the valleys along the major streams, most of the aquifers in the area that is tributary to the Ohio River have yields less than 5 gpm.

Three-quarters of Ohio's 650 public water supply systems use ground water as their source. In terms of volume withdrawn, however, a lesser share of these supplies comes from ground water, for only around a half billion gallons of ground water are withdrawn each day for public water supply purposes, while over one billion gallons come from surface water sources. However, ground water supplies nearly 80 percent of the rural water needs in Ohio, 32 percent of the irrigation waters and 21 percent of the industrial water demands. Nearly one billion gallons of ground water are withdrawn in the state each day to meet these needs.

Water Quality

It is the quality of water, rather than its quantity, that is the more critical and limiting condition associated with the use of both ground and surface waters in Ohio. The ground waters of the state frequently have relatively high, natural mineral contents; but, except for a few local areas, most of these waters are free from man-related contamination. Most complaints are related to increased levels of turbidity, bacterial populations and other substances from improperly sited or poorly constructed or maintained wells. Other problems are related to the spillage and leakage of brines and petroleum at oil wells in the southeastern part of the state; the mis-application of pesticides, herbicides and insecticides in agricultural areas; and the improper siting and operation of solid and liquid waste disposal facilities. Some minor ground water problems associated with the excessive use of highway de-icing salts or its improper storage have also been reported.

The dissolved solids concentrations in Ohio's streams range between 120 and 2,500 milligrams per liter (mg/l). The higher concentrations are found in Tuscarawas, Cuyahoga and Grand Rivers and in other stream reaches below major municipal and industrial outfalls or in areas subjected to diffuse source runoff.

Of the 23,000 miles of the principal rivers downstream of major urban areas in the state that have been monitored, 16,000 miles, or 70 percent of these streams, meet the current water quality standards. Where problems do exist, they are frequently caused by inadequate municipal wastewater treatment at facilities that need to be upgraded or expanded, or by combined sewer outflows. Substantial improvements in surface water quality have resulted from the development of pretreatment regulations for industrial waste discharges to municipal sewerage systems. Violations of the state's water quality standards occur most often in dissolved oxygen levels; ammonia nitrogen concentrations; the numbers of the fecal coliforms; and the levels of heavy metals such as lead, zinc, and cadmium.

Acid mine drainage is a major cause of water quality problems throughout the Appalachian Coal Basin in the eastern United States. In Ohio this region extends in a band approximately 50 miles wide in a southwesterly direction from the east-central to the south-central parts of the state. Acid drainage from abandoned and improperly operated or reclaimed coal mined lands causes a loss of water for domestic and industrial uses; the

degradation of water quality for recreational purposes; a lethal impact on the aquatic life in a stream; and an accelerated deterioration of highway and railroad bridges and electrical transmission lines and towers. Drainage from abandoned coal mines, both surface and underground, has impacted around 1,500 miles of streams in 27 counties in southeastern Ohio. Approximately 370,000 acres of abandoned strip mines, 7,000 acres of coal refuse piles and 3,000 underground mines are contributing to this problem. It has been estimated that four billion dollars would be needed to reclaim the abandoned mines and refuse piles throughout Ohio. Projected revenues from severance taxes earmarked for abandoned mine reclamation come to about ten million dollars annually. Obviously, the technologic problems and the economic costs association with the control of acid mine drainage will continue to keep this a major problem of water quality in southeastern Ohio for years to come.

Little detailed information is available concerning the impacts that diffuse sources of pollution such as agricultural and urban storm water drainage have on the quality of water in Ohio's inland streams. One concern with non-point pollution is the sediment that is dislodged from the land surface and carried to these streams. Of greater concern are the pollutants, such as the nutrients, heavy metals and toxic organic substances, that enter the streams attached to the sediments. No need for intensive, non-point source control programs to meet water quality standards in that area of the state that drains to the Ohio River has been shown; but several studies are underway in the Lake Erie drainage basin to define the role of agricultural drainage on the water quality in the lake. Much more research and many more demonstration projects on the best management practices for agriculture, silviculture, mining and urban runoff control must be conducted before this problem is fully understood and control measures can be instituted.

The trophic status of several lakes and reservoirs has been studied; and the results suggest that the lakes and reservoirs in the sandstone bedrock areas of the state have generally lower trophic levels than those in the limestone bedrock areas or glaciated regions. Water quality was generally good to excellent in most of the lakes and reservoirs surveyed. However, excessive concentrations of copper and other heavy metals, bacteria and other pollutants normally associated with urban activities were identified in some of the lakes. Recent studies on Lake Erie indicate that there has been a reduction in several key pollutants and a gradual, but steady, improvement in the water quality in the Lake during the past few years. Phosphorus is a major pollutant which results in the excessive growth of algae and other aquatic plants. As these plants die and decay, they deplete the oxygen resources of the Lake. The construction of facilities to remove phosphorus at those municipal wastewater treatment plants which discharge directly to Lake Erie has been a major factor in the reduction of phosphorus loadings and of the subsequent reduction of the anoxic areas within the Lake. Additional work on the control of phosphorus from both diffuse sources and point sources needs to be accomplished, but a significant start has been made.

Levels of bacteria have been reduced in the nearshore zones where municipal wastewater treatment facilities have been constructed. This has permitted regulatory agencies to re-open bathing beaches which were often closed during the period between 1960 to 1970. Concentrations of mercury and pesticides have been reduced substantially, principally because of the federal bans that have been instituted on their manufacture, use and disposal. PCB remains a major challenge, as does the control of sediment and the nutrients, fertilizers and organic chemicals that are attached to it.

Fish populations, including the walleye pike, are beginning to increase again in the lake; but the quality and diversity of fish is still far from what they were in the past. Thermal pollution is a localized problem in some near-shore areas. However, as closed cycle cooling is required on all power generation facilities, the extent of this problem will diminish.

Program Goals and Priorities

The Water Resources Center at The Ohio State University encourages and supports research that is directed at providing information needed to solve the major water problems at the local, state, regional and national levels. The research program at the Center includes basic or fundamental research, problem oriented or applied research, and information dissemination and technology transfer activities.

During FY 1982, the Center, in cooperation with several groups of water-related agencies and officials throughout the State prepared a prioritized list of Ohio's major water resources problems. Based upon this analysis, the following ranking of these problems was developed:

1. **Pollution from diffuse sources** - including agricultural runoff, urban runoff, runoff from on-site waste disposal systems; runoff from active, reclaimed or abandoned coal and strip mines.

2. **Contamination of drinking water supplies** - including surface and ground waters for both urban and rural uses by diffuse and point sources, and by the disposal of toxic and hazardous wastes on the land.

3. **Toxic and hazardous waste disposal** - including their control, treatment, disposal and impact upon land, water and air resources.

4. **Pollution from point sources** - including municipal and industrial sources not yet in compliance with their NPDES permits.

5. **Impacts of flooding and drainage** - including flood damages, the use of flood plains and alternative structural and non-structural means of controlling floods and reducing flood damages.

6. **Impacts of water resources developments** - including the impacts on various developments such as the extension of water mains and sewers into rural areas' flood control projects; hydro-electric power generation; water-based recreation, etc.

7. **Instream flow needs** - including interrelationships among water quality, water quantity and land use practices on the instream flow needs for fish, wildlife, recreation and the optimum development and protection of these instream uses.

8. **Impacts of synthetic fuel development** - including requirements for water and impacts of the disposal of wastes from these processes into water and onto the land.

9. **Impacts of atmospheric pollution** - including the effects of acid precipitation and atmospheric fallout on water quality and the environment.

10. **Allocation of water resources** - including the development of contingency plans for the allocation and conservation of limited water supplies among competing water users during periods of low stream flows.

Subsequently, the Directors of the Water Resources Research Institutes in the Great Lakes, Upper Mississippi and Ohio River Basin's met to identify from their State problems the major water resources research priorities for the Region. A listing of these priorities is included at the end of this Section of this Report.

The focus of the 1993 State Water Resources Research Program was primarily directed at some of these critical needs. The technology transfer programs of the Water Resources Center continued to disseminate information about the water resources of Ohio to the local and state decision-makers, and provides technical assistance to help resolve some of the state's major water problems. Three research projects were continuation projects of the FY 1993 water resources research program and the technology transfer program substantially expanded the development of the Ohio Water Education Program area.

The technology transfer program continued to work closely with the water professionals throughout the state and nation in cooperative efforts, jointly sponsored programs, newsletters and reports. The Ohio Water Education Program, (OWEP) provides current information on all water education activities in Ohio and helps teachers network. It also provides K-12 water resources education through Project WET. Ohio State has the lead in a seven state pilot project with the Department of Energy, on environmental management and restoration of DOE sites.

The project by Keith W. Bedford was an oceanographic dynamics study, using mathematical models to calculate how contaminant loading from rivers during and immediately after storms will interact with the Great Lakes Forecasting System. This project entitled "A Nearshore Coliform Prediction and Forecasting System for CSO Hazard Warning" will provide accurate and timely loading figures for the study.

The research by Gerald Matisoff of Case Western Reserve University on "Radium and Uranium Chemistry and Transport in Ohio Major Ground Water Aquifers", developed a technique for analyzing the natural radioactive substances in groundwater and conducted a state-wide survey of their concentrations in the major water supply aquifers. There had been no previous state-wide uranium, thorium and radium surveys in Ohio. Twenty seven wells were sampled by USEPA as part of the National Inorganics and Radionuclides Survey (NIRS); and public health relared ground water surveys have been conducted in the vicinity of DOE facilities in Fernald and Portsmouthm and near the Industrial excess landfill in Stark County; a nd gross alpha levels were studied in Wood County.

"The Effects of Cosolvent Mixtures on the Environmental Chemistry of Metal-Ligand Complexes" was studied by Professors Samuel J. Traina and John W. Olesik of Ohio State. This research is a comprehensive study of the behavior of organically-complexed metals in solutions comprised of aqueous and nonaqueous solvents.

SYNOPSIS

Project No. 02

Start: 7-1-94 (actual)
End: 6-30-95 (expected)

Title: A Nearshore Coliform Prediction and Forecasting System for CSO Hazard Warnings

Investigator: Bedford, Keith W., The Ohio State University, Columbus, Ohio

Focus Categories: CP, MOD, ST, WQL

Congressional District: Fifteenth

Descriptors: transports, forecasting, tributary loading, numerical modeling, Great Lakes

Problems and Research Objectives:

Due to the important role played by coastal regions there is considerable interest in predicting the effects of natural forces and the impacts of human activity on coastal zones. Natural phenomena like storm surges, lake seiches, and wind driven waves can adversely impact coastal regions. Man-made disasters like the Exxon Valdez oil spill threaten coastal areas, as does the not so grand but more frequent problem of combined sewer overflow. Organizations in charge of managing coastal regions need reliable methods of calculating spill and release trajectories in order to respond to severe events and plan for remediation of common ones. This requires numerical models that can sufficiently account for the dynamics of coastal regions.

The particular region of interest for this study is the Great Lakes of North America. The Great Lakes undergo a yearly temperature cycle including the formation of a stable thermocline. These thermoclines exist until autumn weather systems break them down. For Lake Ontario, the thermocline is typically developed by late June, reaches its peak vertical development in August, and lasts until late September or early October (see Boyce et al. [1] and Boyce et al. [2]). The existence of the thermocline induces a density gradient (pycnocline) in the lake since the density of fresh water is primarily temperature dependent. In salt water systems, density is a function of salinity and temperature so that a thermocline might not lead to a pycnocline. A strong pycnocline will set up a two layer system in the lake which affects wind driven circulation, and leads to the formation internal waves on the interface which will also affect lake currents. Further, the exchange of momentum, dissolved chemicals and sediment will be inhibited by the presence of the pycnocline.

A thermocline resolving model can be incorporated into the Great Lakes Forecasting System (GLFS), currently in use at Ohio State University. GLFS is used to generate nowcasts of lake conditions for Lake Erie four times a day, and forecasts of lake conditions for special cases. GLFS is planned to be expanded to the other Great Lakes during the mid 1990's.

In order to model the development and transformation of the thermocline some special effort will be required. The depth to length ratio of Lake Ontario can help to illustrate this point. Lake Ontario is 311 km long and has an average depth of 86 m, yielding a depth to length ratio of 2.76×10^{-4}. A piece of notebook paper is 0.008 cm thick and 28 cm long, yielding a depth to length ratio of 2.86×10^{-4}. This illustrates the necessity of handling the vertical

structure differently from the horizontal. Field observations also point to the dynamic nature of the thermocline. In particular, how the depth and thickness of the thermocline can vary considerably over the course of days as shown in Figure 1 of Saylor [18]. The figure shows the thermocline responding to an internal Poincare wave.

The method that GLFS uses to better resolve the vertical processes is based on the sigma coordinate transformation (terrain following coordinate). However, the vertical resolution is limited under the sigma transformation due to numerical constraints. The problem first isolated by Haney [9] in 1991 is caused by the the combination of bottom slope and depth. The so-called Haney constraint limits the amount of vertical resolution once a horizontal resolution has been selected. Increases in horizontal resolution are in turn limited by computing resources.

To clarify the effects of this constraint, consider the Lake Erie model currently in use under GLFS. With a 2 km grid resolution, the Haney constraint allows for the use of 14 layers in the vertical. In the deepest parts of Lake Erie, that results in a 4.6 m vertical spacing which is minimally adequate to resolve a 9.2 m wave length disturbance (Nyquist frequency) and inadequate to resolve the thermocline in Lake Erie. In Lake Ontario the Haney constraint may allow for more than 14 levels based on bathymetry, however Lake Ontario has a maximum depth of 245 m, much deeper than Lake Erie's 64 m maximum depth. 54 vertical levels are needed to have a 4.6 m resolution. Even if this did not violate the Haney constraint for Lake Ontario, it would leading to a total of 362,232 grid nodes for a 2 km horizontal resolution, and about 1.5 million grid for the planned 1 km resolution. This compares with the 124,936 nodes in use for the Lake Erie model and would strain the computing resources of the Cray Y-MP at OSC, while leaving the thermocline no better resolved.

In order to resolve the thermocline, an adaptive grid packing scheme will be employed. The adaptive grid method is a new formulation described by Dietachmayer and Droegemeir [6] of techniques used by the aeronautical and astronautical engineering communities. This method packs grid nodes more densely in regions with high gradients. The grid is then recalculated each time step to follow the density gradients as they move. The technique is called continuous dynamic grid adaption (CDGA).

Once the thermocline is properly resolved, questions surrounding the dynamics and breakdown of the density structure can be addressed. The existence and behavior of internal Kelvin waves can be verified. Different turbulence closure strategies can implemented and compared. Finally, this can be verified with data from the International Field Year for the Great Lakes (IFYGL) study done in 1972 on Lake Ontario, which has extensive thermal structure data [18]. In summary, the goal of this project is to model the thermocline using adaptive grid techniques, and then to compare the results with the current GLFS model (Princeton Ocean Circulation Model POCM) and with the field data, the IFYGL data set.

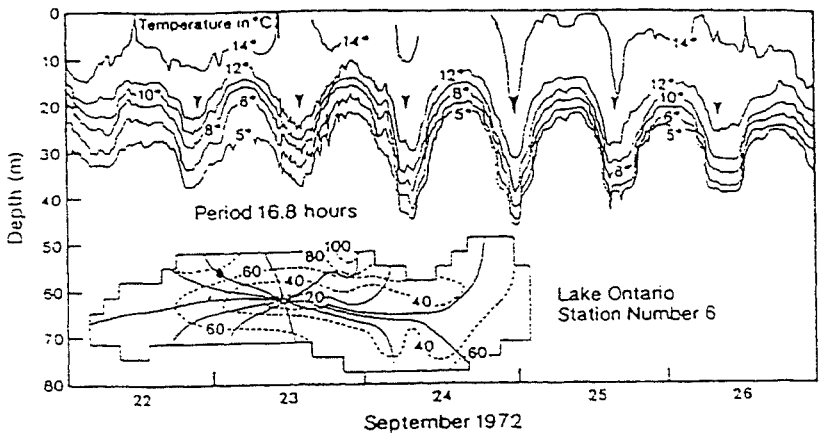


Figure 1. Isothermal depth interpolated from temperature at 17 fixed depths at station 6, September 22-27, 1972 (Boyce 1974).The lower inset shows the amplitude and phase distribution and period (16.8 h) calculated by Schwab (1977) for the lowest Poincare - type mode in a two-layered Lake Ontario model with constant-depth layers...(From Mortimer (1977).

Methodology:

The governing equations described below is the set of equations that are to be solved by both the POCM and the CDGA model. They are standard shallow water equations which include the equations of conservation of mass, momentum, and energy, details about the derivation of these equations can be found in books by Pedlosky [14] and Fung [8].

The transfer of momentum through the lake surface is based on a model used in GLFS and developed at the Great Lakes Environmental Research Laboratory (GLERL). The model was developed by Schwab [19] and Liu and Schwab [10] and is based on the work of Long and Shaffer [11], Businger et al. [4] and Smith and Banke [20].

Heat flux through the lake surface will be calculated again by following the procedures used in GLFS for Lake Erie, which are based on the work of McCormick and Meadows [12]. Riverine inputs and outflows will be accounted for by adding mass, momentum, and heat at the appropriate grid nodes.

Standard Grid Method:

The standard grid method used is a terrain-following coordinate system such as the one employed in Podber [15] and Podber and Bedford [16]. This transformation maps the physical domain into a rectangular computational domain. This approach is common to oceanographic models and is a feature of the POCM. A general description of the terrain following system is provided here, a detailed analysis can be found in Podber [15].

The coordinate transformation T obeys:

$$T: \quad x' = x$$
$$y' - y$$

$$\sigma = \frac{Z-\eta(x,y,t)}{H(x,y,t)}$$

Where $H(x, y,t) = H(x,y) + \eta(x, y,t)$

so that σ ranges from [-1,0]. The variable h(x,y) represents the water depth relative to the still water level and $\eta(x,y,t)$ is the distance from the water surface to the still water level.

Adaptive Grid Techniques:

A second type of tranformation that will be used is called the continuous dynamic grid adaption (CDGA) technique. Originally developed for aeronautical and astronautical problems, CDGA was adapted for meteorological application by Dietachmayer and Droegemeier [6] in 1992. CDGA was further explored in terms of efficiency by Dietachmayer [5] and by Fiedler and Trapp [7], who extend CDGA to three dimensional problems. A broad review of the use of nested, adaptive and other grid techniques in meteorology is found in [6]. The CDGA is based on the forumulations proposed by Brackbill and Saltzman [3] and Saltzman and Brackbill [17]. They create functionals to be minimized based on satisfying a linear combination of three parameters that describe (a) the smoothness of the grid, (b) the orthogonality of the grid, and (c) the density of grid points. The Euler function, from the calculus of variations, is then formed which yields a coupled set of non-linear partial differential equations. These equations are then finite differenced and solved to yield the position of the grids in (x,y,z,t) space. Once this is known, the Jacobian of the transformation can be calculated numerically and the derivatives transformed numerically, as with other grid schemes.

An example of a two dimensional buoyant plume was worked in Fiedler and Trapp [7]. In figure [2] are pictures of the initial buoyancy field and the grid associated with that field and the same at t=4, after the plume has been released.

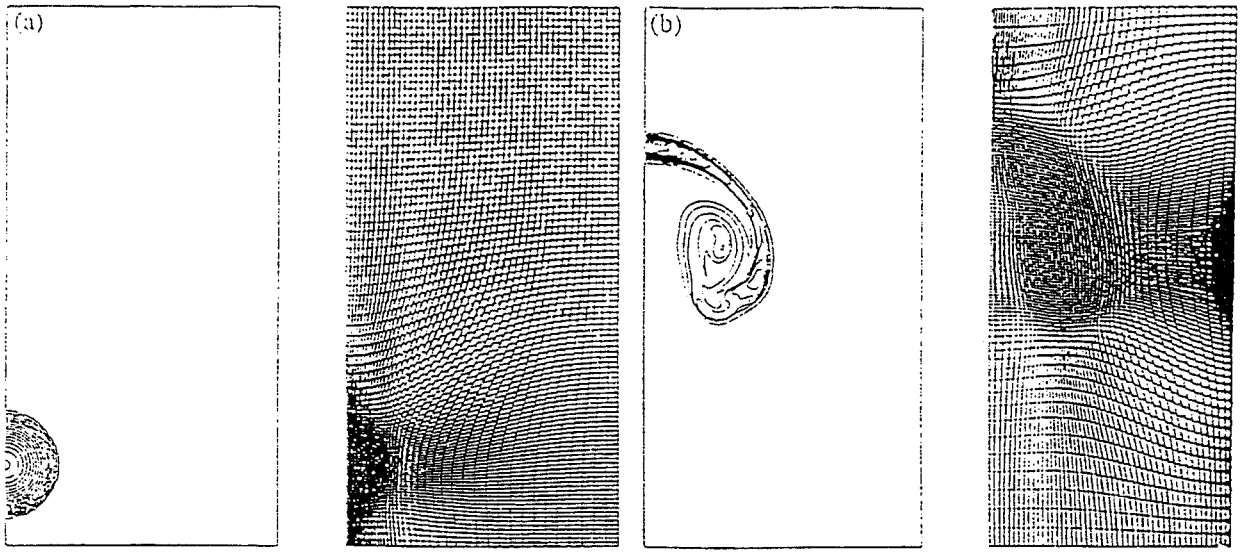


Figure 2. Buoyancy b and u nodes of the full grid at (a) $t = 0$ and (b) $t = 4$ in the two-dimensional 49 x 97 CDGA model. The contour interval is 0.06. The maximum buoyancy values are 1.00 and 0.554 at $t = 0$ and $t = 4$, respectively. All the major extrema are maxima.
Taken from Fiedler and Trapp 1993

This computation is dependent, as are all, on the accuracy and stability of the numerical methods used. In addition the adaptive grid must be calculated with the same numerical accuracy that the governing equations are solved with. Fiedler and Trapp [7] also found that calculating the CDGA was expensive and approximately doubled the computation time. We believe that a parallel version of the problem is possible, so that the grid calculation could be done without increasing run times.

Progress and Results:

Progress over the last year has been made for each of the three tasks. Firstly, the IFYGL data has been accessed via the National Climatic Data Center (NCDC) in the Washington D.C. area. They have sent the relevant data to which preliminary analysis has begun. A test period has been identified, August 8-10, 1972. During this period strong winds setup an internal seiche that travelled across Lake Ontario from North to South. The seiche was recorded using thermal structure data primarily recorded by ships making Lake Ontario transects. The specifics of this event have been reported by Mortimer [13], yet no modeling attempt to date has successfully replicated the event. During this storm event, Lake Ontario was heavily montiored with a suite of buoys, land stations, towers, and coastal chains. Meterological and limnological data were gathered, so that atmospheric inputs of heat and momentum can be sufficiently modeled.

Secondly, the POCM has been ported to Lake Ontario. A 1 kilometer computation mesh was created, using the NOAA 2 km mesh and navigational charts. An Ohio Supercomputer Center account has been granted and initial test runs of the POCM for Lake Ontario have begun.

Lastly, the CDGA model is under development. The members of the University of Oklahoma team [7] have made their code available, which is being adapted from atmospheric applications to limnological ones. The use of adaptive grids is not common in oceanography, so some experimentation and verification will be required.

Summary:

The physical phenomenon associated with the formation and persistence of the thermocline in the Great Lakes is not modeled adequately by existing ocean circulation models. This failure is due to the very short spatial scales associated with the thermocline relative to the vertical resolution that is possible numerically and practically. To remedy the problem an adaptive grid method recently employed in the meteorological community will be implemented for Lake Ontario. This will be the first known application of such a technique to a large body of water. This will serve as a platform for testing several turbulence closure schemes in the literature with the aim of accurately maintaining the thermocline and accurately computing its destruction due to fall storms. The data set to be used for comparison is the IFYGL 1972 data.

References:

F.M. Boyce, W.J. Moody, and B.L. Killins. Heat content of Lake Ontario and estimates of average surface heat fluxes during IFYGL. Technical Bulletin 101, Inland Waters Directorate, Fisheries and Environment Canada, 1977.

F.M. Boyce, M.A. Donelan, P.F. Hamblin, C.R. Murthy, and T.J. Simons. Thermal structure and circulation in the Great Lakes. *Atmospher-Ocean*, 27(4):607--642, 1989.

J.U. Brackbill and J.S. Saltzman. Adaptive zoning for singular problems in two dimensions. *Journal of Computational Physics*, 46:342--368, 1982.

J.A. Businger, J.C. Wyngaard, Y. Izumi, and E.F. Bradley. Flux-profile relationships in the atmospheric surface layer. *Journal of the Atmospheric Sciences*, 28:181--189, March 1971.

G.S. Dietachmayer. Application of continuous dynamic grid adaption techniques to meteorological modeling. {Part II}: Efficiency. *Monthly Weather Review*, 120:1707--1722, August 1992.

G.S. Dietachmayer and K.K. Droegemeier. Application of continuous dynamic grid adaption techniques to meteorological modeling. {Part I}: Basic formulation and accuracy. *Monthly Weather Review*, 120:1675--1706, August 1992.

B.H. Fiedler and R.J. Trapp. A fast dynamic grid adaption scheme for meteorological flows. *Monthly Weather Review*, 121:2879--2888, October 1993.

Y.C. Fung. A first course in continuum mechanics. Prentice-Hall, Inc., Engleweed Cliffs, New Jersey, second edition, 1977.

R.L. Haney. On the pressure gradient force over steep topography in sigma coordinate ocean models. *Journal of Physical Oceanography*, 21:610--619, 1991.

P.C. Liu and D.J. Schwab. An comparison of methods for estimating u^* from given u_z and air-sea temperature differences. *Journal of Geophysical Research*, 92:6488--6494, June 1987.

P.E. Long, Jr. and W.A. Shaffer. Some physical and numerical aspects of boundary layer modeling. NOAA Technical Memorandum NWS TDL-56, National Weather Service, National Oceanic and Atmospheric Administration, 1975.

M.J. McCormick and G.A. Meadows. An intercomparison of four mixed layer models in in a shallow sea. *Journal of Geophysical Research*, 93(3):6774--6788, 1988.

C.H. Mortimer. Internal waves observed in Lake Ontario during the International Field Year for the Great Lakes (IFYGL) :1972 part {I}, descriptive survey and preliminary interpretation of near-inertial oscillations in terms of linear channel-wave models. Special Report 32, Center for Great Lakes Studies, University of Wisconsin-Milwaukee, 1977.

J. Pedlosky. *Geophysical fluid dynamics*. Springer-Verlag, New York, second edition, 1987.

D.P. Podber. Modelling Great Lakes tributary flow and transport. Master's thesis, The Ohio State University, Columbus, Ohio, 1991.

D.P. Podber and K.W. Bedford. Tributary loading with a terrain following coordinate system. *In Estuarine and Coastal Modeling* III, pages 475--488. Waterway, Port, Coastal and Ocean Division, American Society of Civil Engineers, 1993. eds. Spaulding, Malcolm L. et al.

J. Saltzman and J.U. Brackbill. *Numerical Grid Generation*, chapter Applications and generalizations of variational methods for generating adaptive meshes. North-Holland, 1982. ed. J.F. Thompson.

J.H. Saylor, J.R. Bennett, P.C. Liu, R.L. Pickett, F.M. Boyce, C.R. Murthy, and T.J. Simons. IFYGL - *The International Field Year for the Great Lakes*, chapter Water Movements, pages 247--324. The National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan, 1981.

D.J. Schwab. Simulation and forecasting of Lake Erie storm surges. *Monthly Weather Review*, 106:1476--1487, October 1978.

S.D. Smith and E.G. Banke. Variation of the sea surface drag coefficient with wind speed. *Quarterly Journal of the Royal Meteorological Society*, 101:665--673, 1975.

SYNOPSIS

Project No: 03

Start: 07/93 (actual)
End: 06/96 (expected)

Title: Radium and Uranium Chemistry and Transport in Ohio's Major Ground Water Aquifers

Investigators: Matisoff, Gerald, Case Western Reserve University
Khourey, C.J., Ohio Environmental Protection Agency
Ketterer, Michael, John Carroll University

Focus Categories: RAD, HYDGEO, WQL

Congressional District: Twenty-first

Descriptors: Uranium, Thorium, Radium, Groundwater Sampling, Analytical Methodology, Hydrochemistry, Ohio

Problem and research objectives:

The determination of uranium, thorium and radium in ground waters has been hindered by high analytical costs and low throughout. The project work involves the use of ICP-MS methodology for the rapid analysis of uranium, thorium in ground water samples. In addition, ICP-MS and gamma spectrometry will be studied for analysis of radium in ground water. While the first two years of the project focused on uranium and thorium, the third year will focus on radium.

Methodology:

For uranium and thorium analysis, a Fisons PlasmaQuad ICP-MS equipped with a Cetac ultrasonic nebulizer was used for the first year, and a Perkin-Elmer Sciex ELAN 500 ICP-MS was used during the second year of analysis. To compensate for matrix effects the sample concentrations were determined by ratioing the responses of uranium and thorium to that of an internal thallium standard and a standard reference material (SLRS-2, a riverine reference standard obtained from the Research Council of Canada). Radium pre-concentration methods, including wellhead collection methods, using ion exchange were investigated for use with ground water samples and ICP-MS and gamma spectrometric analysis.

Principal findings and significance:

Proposed USEPA rules set the public drinking water MCL for uranium at 20 ug/L, the MCL goal for uranium is proposed at zero. This rule will lead to additional sampling and removal treatment for uranium, with subsequent NORM (Naturally Occurring Radioactive Materials) disposal needs. Additional data was needed on Ohio aquifers to determine ambient levels for uranium. Thorium, having an extremely low solubility in ground water, was included in this study for analytical method development. Based upon our modified USEPA method 200.8, ICP-MS can be seen to be sufficiently sensitive, rapid, and cost effective to permit accurate determination of these samples in ground water samples at trace and ultra-trace concentrations. Using both method 200.8 laboratory fortified water replicate method for determination of precision and detection limit as well as spike

recovery analysis for 10 percent of all samples has demonstrated a method detection limit of 0.010 ug/L for both uranium and thorium in ground water samples having Total Dissolved Solids concentrations of less than 1000 mg/L. Our findings indicate that this method is sufficiently sensitive to detect and quantify uranium in approximately 95 percent of all water samples collected from the Ohio EPA ambient network. Comparisons of filtered and unfiltered samples conducted on 10 percent of sample sources demonstrate that the uranium is dissolved in the source aquifers. Thorium, conversely, was detected and quantified in approximately 15 percent of samples. Due to the low solubility of thorium, additional work may be needed to determine the nature of the thorium, as dissolved or adsorbed to suspended solids.

The first two years of the study included sampling and analysis of the Ohio EPA ambient network for uranium and thorium. Samples collected in the spring of 1993 and the fall of 1994 were analyzed for total uranium and thorium. These samples represent all major aquifer systems in Ohio, with supplemental samples collected from low yield private wells. While uranium was present and measured at levels above 0.010 ug/L in 95 percent of samples, there were no levels exceeding of the proposed MCL of 20 ug/L.

Uranium and thorium analyses were conducted during the first year at the BP research and Environmental Science Center using a Fisons PlasmaQuad ICP-MS equipped with a Cetac nebulizer. The only sample preparation required was a 1:10 sample dilution (one part sample to 9 parts diluent) with a thallium solution to reduce the concentration of dissolved solids introduced to the instrument and to add the internal thallium standard. During the second year, uranium and thorium analyses were conducted at the Department of Chemistry of John Carroll University using a Perkin-Elmer Sciex ELAN 500 ICP-MS and a pneumatic nebulizer. Sample preparation for this instrument required a 10:1 dilution (9 parts sample to one part diluent) with a thallium solution to add the internal thallium standard. By ratioing the responses of uranium and thorium to that of the thallium internal standard, the method compensates for matrix effects. Both methods achieve a minimum sample detection limit of 10 nanograms per liter (10-3 ug/L) for both uranium and thorium in typical ground waters which may contain appreciable concentrations of sodium, calcium, magnesium and total dissolved solids. Accuracy and precision at 100 nanograms per liter are better than two percent relative. The linear range is at least five orders of magnitude. Each set of 10 samples was followed by analysis of quality control standards and a blank. Reference material SLRS-2, a riverine reference standard obtained from the Research Council of Canada, was used with laboratory prepared standards for ultra-trace standardization of the instruments. Thorium was referenced to laboratory prepared samples only.

Spike recovery was determined for 10 percent of samples. Method detection limits were established using USEPA method 200.8 for replicate analysis of laboratory fortified water samples. A sample detection limit of 1.5 nanograms per liter is achievable if samples contain extremely low levels of dissolved solids, are diluted only 1:10 and analyzed using the Cetac ultrasonic nebulizer followed by ICP-MS. For typical ground wafer samples, a detection limit of 10 nanograms per liter can be achieved. Extreme care was taken in preparation of all samples and standards for ultra-trace analysis.

Sample dilutions and standards were prepared by weight to improve accuracy and precision of measurement. Method development for radium analysis in ground water samples was conducted during the second year. Two principal approaches to preconcentration of radium are in development. The first involves the use of cation exchange resins for the purpose of sample volume reduction and selective cation removal prior to ICP-MS analysis. The second method incorporates cation exchange resins in a wellhead radium adsorber column for radium preconcentration on resin devices for later gamma spectrometry. The methods may be used in combination for method comparison.

We utilized the Ohio EPA Ambient Ground Water Quality Network to obtain ground water samples for U and Th analysis. These sample sites were selected because they provide representative ground water from each of Ohio's major aquifer systems. Each sample was analyzed for major cations, anions, and regulated metals by the Ohio EPA Division of Environmental Services as part of the standard ambient program. In addition to these samples, low yield well samples were obtained from private water wells throughout Ohio to supplement the typically high yield well source ambient data.

The Ambient Network of the Ohio EPA is a system designed to document and to track temporal changes in ground water quality. This system has grown from 12 wells in 1967 to 157 active sites in 1995. Wells in the network include public water supply wells and industrial wells in a 4:1 ratio. Samples are generally collected semi-annually. Wells located in buried valley aquifers comprise 66 percent of the network and 34 percent of the wells are completed in consolidated rock aquifers.

All wells are purged prior to sample collection, and samples were collected at the wellhead or the nearest practical point to the wellhead. Samples were collected prior to any water treatment or chemical feed devices. Sample preservation with nitric acid to pH<2 at the time of sample collection was the only preservation required. Samples were shipped to our laboratories for analysis of uranium and thorium, which were performed within 6 months of sample collection.

A total of 169 water wells were sampled for this study. Ambient network high yield wells provided 130 samples, and low yield domestic wells provided 39 samples. Uranium was detected above the detection limit of 10 nanograms per liter in over 95 percent of the samples. Quantified levels were within the range of 10 to 7000 nanograms per liter. Samples below the detection limit of 10 nanograms per liter represented 2.3 percent of the total; with 17.8 percent of samples from 10 to 100 nanograms; 45.0 percent of samples from 100 to 1000 nanograms per liter: and 34.9 percent of samples from 1000 to 10000 nanograms per liter. None of the samples exceeded the proposed MCL for uranium of 20 ug/L. Thorium was detected above 10 nanograms per liter in only 15 percent of samples.

There have been no previous state-wide uranium, thorium and radium surveys in Ohio. While there has been screening of public drinking water supplies for total alpha and beta activity, only limited studies have been done for radionuclides. Twenty seven wells were sampled by USEPA as part of the National Inorganics and Radionuclides Survey (NIRS); and public health related ground water surveys have been conducted in the vicinity of DOE facilities in Fernald and Portsmouth, and near the Industrial excess landfill in Stark County; and gross alpha levels have been studied in Wood County.

Publications:

Khourey, C.J., A.W. Varnes, and G.Matisoff. 1993. Direct determination of ultra-trace uranium and thorium in a state-wide ground water survey in Ohio by inductively coupled plasma mass spectrometry. 16th Midwest Environmental Chemistry Workshop, Notre Dame.

Varnes, A.W., and C.J.Khourey. 1993. Direct determination of ultra-trace uranium and thorium in ground water samples by inductively coupled plasma mass spectrometry. Cleveland Section, American Chemical Society Meeting-in-Miniature.

Khourey, C.J., A.W.Varnes, and G.Matisoff. A state-wide ground water survey for uranium and thorium using ICP-MS. Manuscript in preparation.

Training Accomplishments:

The project has assisted in the support of 1 Ph.D. student: Christopher J. Khourey. Mr. Khourey has a Master's degree and is now beginning the third year of his doctoral program. As Mr. Khourey supervises the work of 9 other hydrogeologists in the Ground Water unit of the Ohio EPA's northeast district office, this training has direct benefit to the environmental programs of the state of Ohio through the continued professional development of Mr. Khourey and the assistance and training that he provides to his staff.

SYNOPSIS

Project No: 04

Start: 07/93 (actual)
End: 06/96 (expected)

Title: Effects of Cosolvent Mixtures on the Environmental Chemistry of Metal-Ligand Complexes

Investigators: Samuel J. Traina and John W. Olesik, The Ohio State University, Columbus, Ohio

Focus Categories: WQL, TS, HYDGEO

Congressional District: Fifteenth

Descriptors: heavy-metals, metal-ligand complexes, chelates, methanol, acetone, thermodynamics, analytical chemistry

Problem and research objectives:

This research will determine the effects of aqueous-organic cosolvent mixtures on the environmental chemistry of toxic metal-ligand complexes. Contamination of soils with mixtures of toxic (and in many instances, radioactive) metals, complexing organic ligands, and organic cosolvents, is a problem receiving growing national attention. These mixed contaminant systems are commonly associated with past and current production of nuclear materials for the nuclear power and weapons industries. The most notorious incidents of this pollution occurred at the Department of Energy (DOE) sites such as Mound, Fernald and Piketon, Ohio; Hanford, Washington; Oak Ridge, Tennessee; Los Alamos, New Mexico; and Livermore, California (1). However, this mixed contamination can occur in other waste environments (landfills, hazardous waste sites, solvent washing of contaminated soils, etc.) Typically this type of contamination resulted from the use of organic solvents containing chelating ligands such as citric acid, oxalic acid and ethylendiaminetetraacetic acid (edta) in the extraction of U and Pu from spent fuel rods. The resulting mixtures also included fission by-products, other metal ions associated with nuclear fuel rods and metals present in the walls of the extraction vessels. Indiscriminate disposal practices, and unintentional releases resulted in the presence of these complex chemical mixtures (metals, organic ligands and miscible organic cosolvent) in soil and groundwater. Additionally, organic solvents were often used to clean machine tools at manufacturing facilities such as Fernald, Ohio, and the Idaho National Engineering Laboratory. At both locations, the solvent washes became contaminated with radioactive metal filings which were inadvertently allowed to react with the surrounding soil, where they became exposed to naturally occurring organic acids such as fulvic and humic acids. It has been suggested that this also resulted in the formation of metal-organic ligand complexes in the mixed solvent solutions (1).

Clearly, contamination of soils, sediments, and ground water by these complex mixtures is a serious environmental problem. Unfortunately, little is known about the environmental chemistry of metal-organic ligand

complexes in aqueous-organic cosolvent solutions, yet and understanding of this chemistry is considered essential in predicting the fate of these toxic mixtures in surface and subsurface environments (1). The problem is further compounded by a general lack of conventional analytical methodologies which can be used to quantify organically-complexed metals in cosolvent solutions. The proposed research will address these deficiences by adapting existing analytical methodologies (lanthanide ion probe spectroscopy, uv-vis spectroscopy and capillary electrophoresis-inductively coupled plasma) to work in these mixed solvent systems. Preliminary studies indicate that these methods can be utilized in methanol-water and acetone-water solutions. We will utilize these techniques to study the effects of solution composition (pH, ionic strength, mole fraction of organic cosolvent, etc.) On the formation of metal-organic ligand complexes in selected cosolvent solutions. This data will be used to refine existing models of electrolyte chemistry in nonaqueous solvents and incorporate these into standard geochemical speciation computer models such as SoilChem (2). Finally, we will study the effects of cosolvents on the adsorption and transport of toxic metal-ligand complexes in soils and subsurface materials. This will facilitate better predictions of contaminant migration and aid in site remediation.

The objectives of the present study were:

1. Adapt existing analytical methodologies (lanthanide-ion probe spectroscopy and uv-vis absorption spectroscopy) and develop new methods (combined high speed capillary electrophoresis and inductively coupled plasma spectroscopy) for measurements of metal-ligand complex formation in model cosolvent mixtures.

2. Modify existing electrolyte theory to allow for the calculation of ion-activity coefficients in model cosolvent mixtures.

3. Apply the analytical methodologies and modified electrolyte theory to describe the effects of selected cosolvent mixtures on the behavior of selected metal-ligand complexes in Ohio soils, soil separates and specimen sorbents.

Methodology:

Analytical Two basic strategies will be employed to measure the complexation of metals by organic ligands in mixed solvent systems. The first method will be a variant of the lanthanide ion probe spectroscopy developed by Dobbs et al. (3). This method exploits the hypersensitive transitions in the fluorescence emission spectrum of the Eu^{+3}. The fluorescence emission spectrum of Eu^{+3} is dominated by two peaks centered 589 and 615 nm. When present as the free metal ion, the peak of 589 nm is of greater intensity than the peak at 614 nm. When a strong ligand penetrates the primary solvation shell of Eu. the relative intensities of these two peaks changes. The changes in the relative peaks intensities can be used to determine the amounts of free and complexes Eu.

In the present study, the Eu-ligand association constants will be measured in each cosolvent mixture, by titrating $Eu(ClO_4)_3$ solutions with each ligand, in a Perkin-Elmer LS5-B spectrofluorometer. A constant pH value will be maintained throughout with the use of an automatic titrator. Values of pKa for each organic ligand, in each cosolvent, will be determined with potentiometric titration (4). Complexation constants for Co, Cu and Pb will then be obtained by competitive titration with Eu, in the presence of each ligand, and each cosolvent solution.

When appropriate, metal complexation by the organic ligands will also be measured by uv-vis absorbance.A combination of highly efficient separation based on capillary electrophoresis (5) and a highly sensitive, selective detection system (inductively coupled plasma emission or mass spectrometry) will be developed in order to separate hydrated metal ions and different metal-ligand complexes in times of a few seconds. Using this approach, and varying the separation time, it should be possible to obtain complete speciation for systems with half-lives of about 0.5 seconds or longer.

Computational Addition of organic cosolvents to water results in decreases in the dielectric constant of the solution. This will decrease the solubility of ionic species, promoting the formation of metal-ligand complexes. In theory, the complexation constants for metal-ligand complexes in aqueous-organic mixed solvents (Kis) can be calculated from the aqueous complexation constants (Kiw) by:

$$K_i^w = \gamma_m^c * K_i^s/\gamma_m^+ * \gamma_m^- \qquad (1)$$

where $\gamma_m^c\gamma_m^-$ and γ_m^- are the transfer activity coefficients for the complex, the free metal ions and the free organic ligands respectively. In the absence of specific interactions between the solutes and the organic cosolvent molecules, these transfer activity coefficients can be calculated with the Born model:

$$\log\gamma_m^i = 121.6(1/_s\epsilon - .0128)/r \qquad (2)$$

where r is the ionic radius of Å and $_s\epsilon$ is the dielectric constant of the cosolvent-water mixture. Unfortunately sufficient interactions (H-bonding, dipole-induced dipole, etc.) Occur between the solutes and the nonaqueous solvent molecules to render useless any calculations of transfer activity coefficients with the Born equation. In the present study, we will calculate transfer activity coefficients from published association constants in pure aqueous solutions and our experimentally measured constants in mixed solvent solutions. We will then relate the values of the transfer activity coefficients to the amount of cosolvent present. Attempts will also be made to apply a modified version of the Born equation, to allow for *apriori* calculations of the transfer activity coefficients.

Principal findings and significance:

Initial examination of the luminescence technique showed a lack of sensitivity so we focused on potentiometric methods. We extended aqueous potentiometric titration technique to semi-aqueous solutions. PH is a master variable for chemistry of ionigenic contaminants in solutions. An appropriate pH scale is the starting point for research in semi-aqueous systems. We measured stability constants in water and mixed solvents. Generally, stability increased with increasing organic co-solvent contents for complexation between Co(II) and oxalate, citrate, nta, and edta in water-acetone and -MeOH solutions. An approximately linear log K versus 1/(dielectric

constant ϵ) relationship was observed for most reactions, indicting that the electrostatic effect dominates. The stability of complexes between Cu(II) and edta, however, declined as the content of the organic co-solvent increased, whereas the stability for the Fe(III)(edta) complex remained nearly unchanged. Cupric EPR measurement showed two distinct micro-species of Cu(edta). We found that some stability constants do not depend on the individual co-solvent mixtures. Thus certain model co-solvent systems may be used to estimate constants in unknown co-solvent solutions.

Goethite is one of the most important environmental adsorbents for ionogenic contaminants. Goethite surface protonation in mixed solvents was studied with potentiometric titratimetry.

$$K_{+} = [=XOH_2^{+}]e^{F\psi/RT}/[=XOH][H^{+}]$$

and

$$K_{-} = [H^{+}][=XO^{-}]e^{-F\psi/RT}/[=XOH]$$

were calculated with surface complexation models (SAMs). Apparent surface site density increased with increasing co-solvent contents. An equation integrating electrostatic correction adequately predicted changes of K_{+} from water to mixed solvents. K_{-} was less tractable unfortunately. Surface affinity distribution, f (log K), was calculated with a surface affinity model. Double peaks purported in surface complexation models were not found on f(log K) patterns. Caution should be taken for surface speciation with SCMs.

In the literature, researchers overlooked at the redox between Fe-oxide and Co(edta) complex, which exists at some contamination sites. UV-Vis data revealed that goethite could surface-catalyze oxidation of Co(II) (edta) to Co (III) (edta) by dissolved O_2, which is kinetically unfavorable without the catalyst. Pseudo first-order rate constant k was determined as 0.0078 (SD=0.00024) $hr.^{-1}$ at p[H] 5.0, 0.1 M $(CH_3)_4NCl(Me_4NCl)$ and 3.09 g goethite L^{-1}; k was $\propto$ [goethite]^4 $[H]^{1/3}$ for p[H] 4-6/ In acetone and MeOH water mixtures at p{H} 5.0 and 0.1 M Me_4NCl, k increased continually for the former solvent system, and decreased first and then increased as MeOH content increased for the latter. Since Co(II) (edta) has different environmental behavior than Co(III) (edta), knowledge of oxidation state is important in contamination modeling.

Publications:

Three manuscripts will be submitted to the most circulated and most read refereed technical journals concerning environmental issues: Environmental Science and Technology.

Training accomplishments:

One Ph.D. Student is working on this project, has completed all the requirements for receiving this degree.

Postgraduate employment:

The graduating student is interviewing with a top Fortune 500 company to work in Japan in support of its business growth and expansion in the Asia-Pacific area.

References:

Riley, R.G., Zacara, J.M. & Wobber, F. J., *Chemical contaminants on DOE lands and selection of contaminant mixtures for subsurface science research*; U.S. DOE Office of
Energy Research, Subsurface Research Program L Washington, D. C., 1992; pp.77.

Sposito, G. & Cloves, J. *Soilchem: a computer program for the calculation of chemical speciation in soils;* The Kearney Foundation of Soil Science, University of California, 1988.

Dobbs, J. C., Susetyo, W.; Knight F. E . Castles, M. A. & Carreira, L. A., *Anal. Chem* 1989, *61*, 483-488.

Popovych, O. & Tomkins, R. P. T. *Nonaqueous solution chemistry*; John Wiley & Sons; New York, 1981; pp. 500.

Romano, J.; Jandik, P.; Jones, W. R. & Jackson, P. E. *J. Chromatogr.* 1991, 546, 411.

Information Transfer Activities

The Water Resources Center has been housed in the Agricultural Engineering Building on The Ohio State University campus. This location has provided daily opportunities to work closely and share ideas with researchers in the College of Agriculture as well as the College of Engineering. It has also provided a close working relationship with the OSU Agricultural Engineering Cooperative Extension Service. A series of tasks were continued or initiated to transfer and disseminate information developed by researchers affiliated with the Water Resources Center to a wide range of State, Federal, County and Municipal agencies; to private sector, to the academic community and to private citizens throughout Ohio.

Water Luncheon Seminar

The Water Resources Center continued to co-sponsor four Water Luncheon Seminar Programs for the water resources community in Central Ohio. These programs, are developed cooperatively with The Ohio Department of Natural Resources (ODNR), the Ohio Environmental Protection Agency (OEPA), the Natural Resources Conservation Service (NRCS), the District Office of the United States Geological Survey (USGS) and the Cooperative Extension Service of The Ohio State University. They continue to attract more than 350 water resources professionals annually from Federal, State, County and Municipal Agencies, the private sector and the academic community. These seminars provide a forum to discuss current state, federal and local water policy issues, problems, programs and research results. In addition to providing speakers for one meeting a year, the Water Resources Center provides the administrative and financial support for the seminars. The Center also provides technical equipment and other support to assist the speakers with their presentations. The programs which were presented during the 1994 series follows.

Water Luncheon Seminar FY 1994

Date	Speaker/Agency	Topic
September 29, 1994	Ed Bugliosi/Hydrologist Project Chief for RASA USGS District Office	Summary of Midwest Basins and Arches Regional Aquifer Systems Analysis (RASA) Project
January 10, 1995	Wayne Maresch Assistant Conservationist for Water Resources Natural Resources Conservation Service	Latest Changes in USDA - Natural Resources Conservation Service
March 14, 1995	Tom Behlen, Chief Division of Surface Water John Sadzewicz, Chief Division of Drinking & Ground Waters Ohio Environmental Protection Agency	OEPA: Update on Changes Water Programs
May 16, 1995	Dr. Susan W. Fisher, Professor Department of Entomology The Ohio State University	Man Made Stressors That Affect Aquatic Systems

Other Conferences and Seminars the Water Resources Center Co-Sponsored or Supported in FY 1994

Date	Program	Co-Sponsors
November 9 -10, 1994	Total Watershed Management 23rd Annual Conference -	Water Management Association of Ohio
November 17, 1994	Watershed Planning: What's New, What's Old - *Dr. David H. Moreau* Director, North Carolina Water Resources Center	Ohio State University School of Natural Resources Wayne Nichols Memorial Water Resources Center
February 14, 1995	"WET - The New Wave in Water Resources Education" - *Carol Moody* Water Resources Center	The National Center for Science Teaching and Learning - The Ohio State University
March 15-16, 1995	Project WET Leadership Training Workshop at Proctor Center	Ohio Water Education Program
April 4-5, 1995	Project WET Leadership Training Workshop at Lakeville	Ohio Water Education Program (OWEP)
May 9, 1995	Dam Safety, Floodplain Management and Stormwater Management Awareness Workshops	The Water Management Association of Ohio and the Association of State Dam Safety Officials and the Federal Emergency Management Agency
June 20, 1995	Project Wet Teacher Training Workshop	The Water Management Association of Ohio, The Franklin Soil & Water Conservation District , Water Resources Center

Publications and Information Dissemination Activities

The Center continued meeting with the leading water resources officials in the state for the purposes of sharing information on current water management and policy issues; seeking continued support for our water research program and disseminating the information and technology developed through this program and others at the universities throughout the state and region. A third of the phonecalls to Center and public information about water quality issues.

The Center, continued publishing its newsletter WATER which focuses on Ohio's water research, technology, issues, legislation in process, education and Center activities. This publication has a wide circulation that includes public officials, water managers throughout Ohio, university researchers in Ohio and throughout the nation, as well as the general public. The editor, Carol Moody, is also the Secretary for the Center.

Water Management Association of Ohio (WMAO)

The Water Resources Center continued to be the administrative office for the Water Management Association of Ohio (WMAO). This not-for-profit, 230 member, state-wide organization promotes and supports the development, conservation, control, protection and utilization of the water resources of Ohio for all beneficial purposes. It is the only Ohio organization that is solely concerned with managing Ohio's water. The WRC provides staff support, office space and equipment to WMAO as a portion of the information transfer program.

Ohio Water Education Project (OWEP)

The Ohio Water Education Program (OWEP) began in Ohio in the Fall of 1992 with the Ohio Department of Natural Resources and the Water Resources Center. A Memorandum of Understanding supporting this project has been signed by the Water Management Association of Ohio/Water Resources Foundation of Ohio, the Ohio Department of Natural Resources, the Ohio Environmental Protection Agency and the Water Resources Center.

There are two functions to this program. The first provides a database of water education materials and projects available/on-going in Ohio; a listing of materials and supplies available for the classroom; the lists of people statewide interested in working with teachers to promote water resources education. The second segment of this project is sponsoring the National Water Education Program (National Project WET). This is a national program for students in grades K-12 for interdisciplinary water resources education. Classroom teachers have indicated tremendous interest for this information and classroom materials. More than 120 teachers attended workshops to test the materials with 89 completing and are turning the materials to the National Office. (The greatest response nationally.)

In the Spring of 1995 the Water Resources Center sponsored two facilitator training seminars for 140 individuals this past year. In addition the Center assisted with a 6 hour level workshop in June, and staff has averaged one promotional activity for OWEP each month the past year. The Center also provided all the supplies, interactive models - such as ground water model, Enviroscape and interactive watershed computer simulator, teacher hand-outs, and 1,600 Project WET books. The Center has donated office space, telephone and fax facilities, postage and provided substantial administrative support and services. This project is housed at the Water Resources Center and is a major effort of the information transfer program.

The Department of Energy Project

This is a collaborative, pilot project with seven water resources research institutes nationally. The Ohio Water Resources Center and the Ohio Technology Transfer Center are the lead agencies in this pilot project. Ohio's role is to produce a database of all technologies currently used that could be adapted or applied to remediation of hazardous and nuclear waste sites, such as the Fernald plant in southwestern Ohio. A SUN work station is operational and the database is in development as an are Internet/Gopher protocols. Other locations will test the technologies, provide education programs on progress and produce documentation on the findings.

Cooperative Arrangements

Program Development

A call for pre-proposals for the Fiscal Year 1993 State Water Resources Research Program was mailed to reach administrators and qualified faculty investigators at more than 40 private and public colleges and universities throughout Ohio in mid-November, 1992. This announcement contained the research priorities identified for the major water problems in the Great Lakes, Upper Mississippi and Ohio River Basins by the Water Resources Research Institutes in the Region.

The announcement also required interested researchers to request a copy of the Preliminary Proposal Application Form which was to be completed and returned to the Water Resources Center in late January, 1993.

Pre-Proposals/Federal Guidelines

Preliminary Proposal Application Forms were requested by and sent to twenty-three investigators and research administrators at ten colleges and universities in Ohio. Central State University, an Historically Black University, was one of these colleges, but they did not request any pre-proposal information. In addition to the application form, a list of the federal guidelines for the Program was also enclosed.

Evaluation/Selection Procedures

Seventeen pre-proposals from seven universities and colleges throughout the state were submitted for evaluation and consideration. These pre-proposals were subjected to a review by all of the members of the Water Resources Center's Advisory Committee. In addition, these pre-proposals were distributed to the various divisions within the principal state and federal water-related agencies in the State by the representatives of these agencies who serve on the Advisory Committee, requesting that the divisions review the proposals. The four agencies included I n this evaluation were the Ohio Department of Natural Resources, the Ohio Environmental Protection Agency, the District Office of the United States Geological Survey and the Agricultural Research Service in the United States Department of Agriculture.

The results of these reviews were presented at a meeting of the Advisory Committee where this panel selected six of the pre-proposals and instructed the Center's Director to request fully developed proposals from the investigators for the Committee's further consideration.

The six selected pre-proposals were developed more fully and were re-submitted for consideration. The proposals were subjected to a technical review by at least three qualified evaluators selected by individual members of the Water Resources Center's Advisory Committee. Many of these evaluators were from state and federal agencies.

The results of these reviews were presented at a meeting of the Advisory Committee and this panel ranked the leading proposals in the order they felt would best meet the needs and objectives of the Water Resources Center's programs. The Advisory Committee then instructed the Center's Director to incorporate as many of these projects as Federal funds would permit into the FY 1993 Program, and to develop a project for information transfer for the Center. There was enough Federal monies to support five projects. Three of these projects were two year proposals and the recommendation was to expand the information transfer program in the second year of funding.

The membership of the Water Resources Center's Advisory Committee, which includes representatives from four colleges and ten departments of The Ohio State University and representatives of the principal state and federal water related agencies is included in this report.

Regional Cooperative Initiatives

The projects selected for the FY 1993 Program were compared with the programs of the other Water Resources Research Institutes in the Great Lakes, Upper Mississippi and Ohio River Basin to ensure that there was no duplication of efforts in the Region's research programs.

The Ohio State University has agreed to continue as a Charter Member of the Ohio River Basin Research and Education Consortium, and the Director of the Water Resources Center has continued to serve as one of the University's three representatives to the Consortium.

The Director was appointed by the Governor of the State of Ohio to serve in three capacities (1) as Chair of the Ohio Water Advisory Council for the Ohio Department of Natural Resources, Division of Water, (2) as a member of the Department of Natural Resources Real Estate and Recreation Commission, and (3) as a member of the Governor's Blue Ribbon Task Force on Water Resources Planning and Development. The Mayor of the City of Columbus has appointed him to the Environmental Science Advisory Committee (ESAC) for the city.

Program Management

At least once each quarter, the Director contacts the Principal Investigator on each research and information transfer project to discuss progress made during the quarter and to discuss the next quarters plan of activities. At this same meeting budget details are reviewed and discussed, and necessary operating and reporting procedures to the Water Resources Center and to The Ohio State University Research Foundation's business office are described. Progress Reports or Completion Reports will be prepared for each project by the Principal Investigators and will be used by the Program Director to prepare the Program Final Report.

All of the investigators are urged to publish the results of their findings in the technical literature of their major disciplines and in other journals that are appropriate to the topic of their research. They are also encouraged and invited to present their findings at the Water Luncheon Seminar that is a part of the information transfer program.

The manuscripts that constitute the project completion reports are first reviewed by the Director of the Water Resources Center. As needed the Director seeks the advice and council of appropriate state, federal and university scientists for methods of enhancing the value of the technical completion reports to the water-related community in the state and in the region.

WATER RESOURCES CENTER ADVISORY COMMITTEE

College of Engineering

Professor L-S Fan
Chemical Engineering

Dr. Robert C. Stiefel
Director, Water Resources Center

Dr. E. Earl Whitlatch
Civil & Environmental Engineering

School of Architecture

Dr. Steven I. Gordon
City and Regional Planning

Professor J. W. Simpson
Landscape Architecture

College of Biological Sciences

Dr. Jeffrey Reutter
Lake Erie Programs

Dr. David Culver
Zoology

College of Mathematical and Physical Sciences

Dr. E. Scott Bair
Geology

College of Agriculture

School of Natural Resources

Dr. Robert L. Vertrees
Resource Management

OSU Research Foundation

Ms. Theresa Heitzman
Grants Administrator

Ohio Environmental Protection Agency

Dr. John Estenik

Ohio Department of Natural Resources

James Morris, Chief
Division of Water

United States Geological Survey

Steve Hindall
District Chief

United States Department of Agriculture

Dr. Norman Fausey
Agricultural Research Service

Training Accomplishments

Field of Study	Undergraduate	Master's	Ph. D.	Total
Engineering Civil			1	1
Geology Hydrogeology			1	1
Natural Resources Agronomy			1	1
Total			3	3

Postgraduate Employment

Student	Degree BS MS Ph. D.	Government Federal State Local	Private Sector	College or University
Chris Khourey	X	X		
International Student			X	

Chris Khourey is working full time for the State of Ohio at the Ohio Environmental Protection Agency where he has been employed for several years.

The International Student in Agronomy is completing his doctoral thesis and has applied to Fortune 500 companies in Japan.

The third Ph. D. Student on this proposal is attending college as a full-time student.